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Review Aspects of Using Social Annotation for Enhancing Search Engine Performance

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Abstract

Recently, search engines have improved to be more efficient in supporting user's search process. Although they enhanced their capabilities to support user, still searcher spend long times in navigation. This is due to the different nature of users, where users have changeable interest and different culture, domain, and expressions. So, for improving search and make it closed to user's expectation; user's preferences have to be discovered. Nowadays, Information Retrieval researchers concern with Personalized Search which provides user's preferences discovering. In this contribution, many efforts put path extracting user's preferences through follow their behaviors, and action. Recently, researches focus on social annotations as additional metadata that may be used for extracting user's preferences and interests.

This paper reviews different aspects of using social annotation (as additional metadata) for enhancing search engines capabilities. Moreover, it especially focuses on personalized search which became today part of web 3.0 improvements. So, it proposes to categorize efforts in this field into two parts. The first concerns with improving personalized search by extracting user's interests, and the second is for supporting personalized search by linking search phases to standard model.

Keywords: Social Annotation; Personalized Search; ontology.

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1. Introduction

The World Wide Web has a large amount of data that is distributed in a large number of resources in different forms. Search engines perform an important role, as a commercial application, to support user for reaching his/her search purpose [2, 18]. Although search engines have been improved in the last few years, they still suffer from several challenges that affect in retrieval process. Basically, these challenges due to matching techniques which do not make sense about query term's semantics, and the individual differences among users (knowledge, domain, terminologies, and preferences). Thus, the web user may spend a long time in navigation, and upgrade query's keywords to achieve his/her search goal [4, 7, 8]. Then, user's preferences have to be known to support search engines in retrieving results closed to each user expectations.

In the context of Web 2.0, users became part of the web not only recipient. So, there is a stream of motivated web systems that provide web with blogs, social annotations, and social participation [2]. Then, a new level of knowledge has been created which represented in a descriptive way that makes them both machine processed and human understandable [2, 18]. This description is created by providing annotating resources by user's free text which called annotations (tag). Nowadays, annotations may be considered as additional metadata which attach to web resources for describing them. Moreover, annotations may reflect user's interests and preferences.

This paper gives an overview of different aspects of using social annotations which support personalized search. Section (1) is a background about personalizes search, and social annotations. Section (2) categorizes personalized search researches into two categories. Section (3) lists related work based on the two categories.

2. Background

2.1. Personalized Search

Search engines uses keyword matching techniques which are considered as the most popular search techniques. These techniques are based on query's keywords, and keywords' repetition in different resources [19, 22, and 23]. Practically, investigation has indicated that poor user experience-on Google search for 52% of 20,000 queries; searches did not find any relevant results [10]. Basically, this problem is due to three core reasons. Firstly, queries are in general short and nonspecific. Secondly, search engines are affected by problems such as query terms ambiguity and results are ranked based on website popularity rather than user interests [21]. It is based on the popularity of web documents, without consideration about the quality. So, a newborn web document usually cannot get highly-ranked positions due to their freshness and little reputation [23]. Thirdly, a user may have different intentions for the same query (e.g., "jaguar" it may be car or animal), this due to different user's background, culture, and perspectives.

Nowadays, researchers' interests directed for improving Information Retrieval (IR) by considering the user as a part of the retrieval process. This called Personalized Information Retrieval (Personalized Search) [8, 10, and 11]. Personalized Search is "the process of recovering information from several web resources with making a user part of the retrieval process for the purpose of presenting the right information to the right user at the right moment" [11,21]. So, Personalized Search concerns with the user's interests discovery and constructing a

mapping between users and several web resources. The user's interests may be discovered through user's behaviors, navigation, and actions through social networks.

Personalized search requires tracking and modeling user's preferences. So, theses preferences may be extracted by analyzing user's social annotations [4, 8]. Then, theses preferences have to be mapped to annotated resources through a specific model. So, this model may be used for improving retrieval. Personalized search usually uses the constructed model in two main scenarios, either through personalized query expansion, or through re-ranking and filtering search results. Then, search engines may be able to retrieve results that more closed to user's expectations [11, 4].

2.2. Social Annotation

Nowadays, social web became part of the web which concerned with online activities that requiring collaborative user participation [14]. Moreover, social tagging systems have developed to enable users to tag online resources (bookmarks, music, images, etc) with freely chosen non-hierarchical annotations (e.g., tags). *Social annotation* may be defined as "an intuitive, on-line, collaborative process through which each element of a collection of resources (e.g. URL, picture, videos, etc) is associated with a group of descriptive keywords" [11, 6]. It is a form of folksonomy which considered as a web method to label text of web pages, online photographs, and web links [4].

Moreover, Social annotations (Collaborative tagging) may be considered as a good representation of user's knowledge, interests and perception. However, each user has their culture, background and experiences, so everyone tags resources from their point of view and by using their vocabularies. Hence, social tagging systems suffer from several problems such as ambiguity in meaning, tag variation (synonyms) and flat organization of tags.

Social annotations are useful for many applications for the purpose of detecting a variety of trends in collaborative tagging systems facilitate browsing and exploring through of resources, and automatically suggesting personalized tags for a web pages improving search. Moreover, by using social annotations noise and confusing that associated with relevant resources can be eliminated [11], and they can be used to discover user's intended [11, 13, 25].

3. Different Aspects of Using Social Annotation in Personalized Search

Nowadays, IR researchers concern with using annotation as a level of metadata that may reflect obscure semantics and the user's preferences. Their efforts focus on analyzing annotations as well as document content, and consider annotation as a part of document content [9, 26]. This may be due to several aspects; Firstly, the tags are generated by the user from his perspective, and they may be considered as an abstract of the document content. Secondly, the differences of web users' domain expertise, so user's expertise should be discovered. Finally, the numbers of tag's terms compared to document are usually limited, so we can discover semantic of tags easier than document [4, 17, 20].

The Last few years, researches revolved on different aspects of using social annotations for improving search quality. These aspects may be categorized into two categories; improving personalized search by extracting user's interests, and supporting personalized search by adding a level of standardization.

3.1. Utilizing Social Annotation for Extracting User's Preferences

Users face several challenges during search process, where they may spend a long time to keep their search goals. These challenges may be eliminated if search engines concern with changeable and complex user preferences. So, social annotations may be an instrument that contributes in extracting user's preferences. In this context, there are several efforts to construct a user profile which represent different user's interest. The user profile represented knowledge infers by analyzing user's annotation through different resources.

Recently, many Information Retrieval (IR) researchers concern with annotations analysis as well as document content analysis; where they considered annotation as a part of document content [3, 19]. This may be due to several aspects; First of all, annotations are generated by the user from his perspective, and they are considered as an abstract of the document content. Secondly, the differences of domain expertise of users, some users may give incorrect tags. So, the user expertise should be discovered. Finally, the numbers of tag's terms compared to document are usually limited, so we can discover semantic of tags easier than document [4, 19].

Basically, user profile can be captured in two ways explicitly and implicitly [19, 21]. The explicit techniques are based on asking user feedback such as preferences or ratings. The implicit techniques are based on follow the user interactions and try to infer the user's interests and preferences (for example, observing user behaviors such as the time spent reading an online document), and representing them in a predictive model. The main methods to extract user's interests are user behavior observation, follow and analysis their behaviors and actions. The observations include browser history, query history, click-through data, desktop information, document display time, bookmarks, etc [19].

However, explicit construction of user profiles has several drawbacks [21]. The drawbacks are the inconsistent or incorrect information which provided by the user, and the static user profile, although user's interests may be changed frequently. Thus, many research efforts are underway to implicitly create accurate user profiles [21]. In order to eliminate these drawbacks, the most recent approach of developing user profile relies on analyzing user interactions through social networks (using comments, blogs, and annotation). So, this may provide a good prediction of the preferences of web users [19].

In general, user's annotation may be classified into two types, each one uses depended on the research purpose. The classification is based on dividing user's action into *descriptive* actions and *reactive* actions. The *distributive* action is attaching document with words to describe its content (tag). In the other side, *reactive* action reflects the user feedback or opinion about the existing document such as: like, dislike, favorite, and comment [15]. The descriptive type serves different areas of research such as improving information retrieval, personalized search, interest mining. Also, the reactive type may be used in emotional analysis researches.

Nowadays, several personalized search efforts (especially which focus on annotation) revolve around interest

mining based on user's descriptive actions. Interest mining is an innovative expression which may be defined as; an exploration and analysis of users' behaviors, actions, and annotations through the web in order to discover valid, novel, potentially useful, and ultimately understandable patterns which represent web user's preferences and interests [27, 9]. It is considered as extension of text mining for supporting Personalized Search [8, 9]. Personalized search may be used several mining techniques in different aspects such as constructing user's profile, developing document model, re-ranking results [28, 8, 9]. These techniques are listed as follow:

- ***Probabilistic Technique:*** it uses graphical representation to compare different knowledge representations. There are several visualization tools which used for facilitating data exploration, testing and evolution. By visualizing patterns the human user can understand them, to help him in perception and discussion making [1].
- ***Statistical Technique:*** it works based on data relationships and discovery rules. There is an inductive learning algorithm can be used to generalize patterns in the data, and to construct rules from the noted patterns [1].
- ***Deviations and Trend Analysis:*** it constructed based on pattern detection by filtering important trends. It applies on temporal database [1].
- ***Classification Technique:*** it aims to group data based on similarity and classes. It is useful for organizing the potential metadata of digital library for knowledge generation process [1]. For example, decision tree approach, pattern discovery, and data cleaning models.

3.2. Utilizing Standard Model for Support Personalized Search

In the context of Web 3.0 which support semantic web, ontology may be a useful and powerful conceptual model. This may be due to its ability to formally define terms shared between several agents. Formally, it is defined as "specification of a conceptualization" [21]. In context of computer and information sciences, ontology defines as a "set of representational primitives which model a domain of knowledge or discourse" [33]. Ontology may be used to Share common understanding of the structure of information among people or software agents, analyzing domain knowledge, and adding a level of standardization. [31, 32, and 29]. Also, ontology can eliminate ambiguity and allow information to be processed automatically and accurately [21, 24]. Recently, many applications use ontology to support different research fields (e.g. bioinformatics, business process re-engineering, database integration, recommendation systems, and social systems). Personalized search (specially based on annotation) suffers from several semantics challenges that may affect on search. The main challenge which may face researches is free text annotation; where each user uses his/her own expressions based on his/her domain, culture, and experience. So, personalized search may suffer from semantic ambiguity problem, where there is no synonym control [13, 16]. Also, flat organization of tags may be representing a challenge, which may affect analysis and retrieval processes. In context of Personalized IR, ontology provides higher level of semantics description and architecture interrelationships among query terms, document keywords, or annotation terms. Ontology may facilitate this by representing metadata as a hierarchy of concepts (class, subclass, instance of, part of …etc) and relationships among them, where this classification supports inference mechanisms for enhancing personalization [17]. Practically, there are great efforts in this field based on utilizing ontology for supporting personalized search and extracting user's interests. These efforts may be

categorized into different levels based on the research purpose. Some researches focus on using ontology for eliminating the annotation flat structure challenge, and others for eliminating semantic and ambiguity problem. Firstly, in context of flat structure challenge researchers supposed to convert annotations from free text annotation into formal annotations. The formal annotations are written by using formal taxonomy extracted from conceptual model (ontology), then they are machine process-able and human understandable. Although, ontology provides annotating web resources with shared and agreed words; this needs the user to be aware enough of ontology structure and its taxonomy but this may be challenging [3]. Secondly, some researchers use ontology for eliminating semantic and ambiguity problem by constructing user model and making an interrelationship among annotator, annotation, and document. So, search engine can enhance its capabilities using the contracted model, and then they may re-rank the retrieved user's query result.

4. Ontology Based Annotation V.S Free Text Annotation in Personalized Search

Free text annotation and ontology are knowledge representation methods have their own advantages and disadvantages. Moreover, the importance of each one differentiates based on research purpose [5, 12]. However, using ontology and annotations in personalized search is still one of research problems which need more efforts [5]. This may due to the need of utilizing both (free text and ontology based) for taking the advantages of each one and eliminate the disadvantages. Table (1) represents a comparison between ontology and free text annotations.

Table 1: Comparison between Free Text Annotations and Ontological Annotation

	Ontology Based Annotation	**Free Text Annotations**
Vocabulary	Agreed taxonomies	uncontrolled vocabularies
Field of application	Bioinformatics & knowledge	General purpose
Ambiguity& misunderstanding	Avoid the problem by using standard model	Using vocabularies from different culture and domain lead to these problems
Synonym control	Controlled	Non controlled
Acknowledgement	Needs the user to be aware enough of ontology terms	Does not need any background about annotation
Guidance	Shared annotations cannot be guide others until they have background of ontology concepts and their semantics	Shared annotations can be a guide to other web users specially whose in the same domain
Representation	Structured & standard model	Flat & unstructured representation
Dependency	System dependent & static	User dependent & dynamic
Cost	Time consuming	Easier in development

5. Related Work

This paper categorizes the previous work in personalized search field based on the above two aspects. This section consists of two sub sections; the first discusses annotation utilization in personalized search, and the second concerns with using ontology and social annotation in personalized search.

5.1. First Aspect: Annotation Utilization in Personalized Search Field

Reference [30] proposed collaborative search method for social media. The proposed method adopted the Bag-of-Tag (BOT) paradigm to construct user and resource profile. The paradigm is mainly based on the assumption that user's tags reflect the user interest to some extent. They focus on investigating three main research questions which are the core of their approach. These questions are:

- how to depict users and resources in the social media;
- how to measure the user similarity in the social media;
- how to assist users to find their interested data (resources) by similar users in the social media.

So, they decomposed their approach into three sub modules, where each one answers one of the above questions. Moreover, they proposed algorithm for classifying users based on their communities. This classification had two stages one of them is off-line discovery and the other is on-line discovery. Then, the user's query results re-ranked based on the above two stages.

Reference [8] proposed social information retrieval based on user interesting mining. It exploited the relation of user interesting, user tags, and web text context. It extends the language model (LM) which is recently being rated to IR, but LM suffers from some problems like data sparseness and term independence assumption. Then, several efforts have been made to develop it for IR based on social annotations. This paper proposed smoothing document query models based on the information generated by clustering and modeling the tagged web. The information includes: the topical cluster distribution of documents, and the users' interest distribution. Based on this information the LM is expanded with user interests.

The evaluation of the proposed approach is done in two levels: the first is by students' judgment (test the retrieval resources through a sample of graduate student), where the number of perfect result sets over 80%, and the number of bad result sets is less than 10%. So, the information retrieval performance of the proposed method is effective. A second evaluation method is by comparing the proposed model to other language model. The result of evaluation emphasized that it realized result probably greater than others.

Reference [9] proposed enhancing web information retrieval by topic tag mining. It improved language model for information retrieval based on three components: topic structures of documents, semantic structures of tags, and user interests. It calculates relation between three parts of the network: social tag, resource, and web user. The result of calculation helps to create links between similar documents. Tag mining is based on calculating similarity by using the vector model between nodes in resources graph.

It proposed to enhance the Language Modeling (LM) approach which supports information retrieval. The task of this approach is to estimate the document model and rank the resulted document based on the query generative likelihood according to the estimated model. In this model, four sub-models are combined together to develop query terms, where the Language Annotation Model, document model, user model, and query model are used together to enhance IR. The proposed approach used the vector space approach for applying it for information retrieval. Moreover, it interested in applying user profile information to personalize a retrieved list of documents returned from a search engine. In this contribution, there are two approaches to personalize the results from an information retrieval system without changing the internal retrieval function of the system. The first approach is to expand the query with new (possibly weighted) terms. The second is to re-rank retrieved results based on similarity to the user profile. Also, they incorporate the user profile for personalized information retrieval by expanding the query with terms from the profile, and weighting them appropriately. However, they limit the number of expansion terms to limit the amount of noise and total length of the expanded query.

Reference [12] explored an approach for supporting semantic web using social annotations instead of formal annotations (ontology based annotations). After filtering tags and explore the related tags for the same resource and the users whom have the related interests; it used co-occurrence to compute frequencies of user's tags, resources and users. The proposed approach made statistical studies on the co-occurrence numbers where the semantics of an entity (web resources, user, and tag) represented as a multi-dimensional vector. Each dimension represents a category of knowledge. Every entity can be mapped to a multi-dimensional vector, whose component in each dimension measures the relativity between the entity and the corresponding category of knowledge. So, the one entity with relates to a special category of knowledge, its dimension has a high score.

Reference [15] proposed a framework for enhancing information retrieval by using both user's profile and documents profile. First of all it creates user's profile based on user's tags. Then, when the user constructs his/her query results are computed based on the topic. Moreover, these results are recomputed based on user's communities and the user reactive action (clicks, e.g. share, like, comment, etc.). Then, the results are re- ranked based on a combination of results from the related content and the social relevance scores for each result.

5.2. Second Aspect: Ontology and Annotation Utilization in Personalized Search Field

Reference [25] concerned with modeling user profile using folksonomy based on global predefined ontology. This for avoiding some challenges that face personalized search engines and recommendation systems. In most of them, the semantics of each tag in the folksonomy have not been utilized very well. As users can freely choose tags using their own vocabulary, the resulting metadata can include homonyms and synonyms. This may lead to misconnections among different concepts and inefficient searches for information about a topic. Another challenge to folksonomy based on user interest model is how to model multiple interests that most of users have. Although various clustering methods had been proposed to split user interests into individual clusters, their performance is not very promising because of their unsupervised nature.

The proposed approach tried to take advantage of both folksonomy and domain ontology. As the tags in the folksonomy are assigned by the user to the resources, they can reflect the user's real interests; otherwise the user

would not label the resources with the tag at all. On the other hand, as the ontology is predefined by domain experts, the concepts in the ontology are accurate and easy to spread to related concepts in the hierarchical tree. More specifically, for building an ontological user interest profile, they mapped user tags in Delicious social bookmarking system onto Web topic ontology (the Open Directory Project taxonomy). So, the semantics of tags in folksonomy are modeled.

References [23] and [35] proposed approaches for developing an ontological user profile for the purpose of personalized search. The profile is being updated and saved into the database automatically, when the user clicks URLs. This approach follows user behaviors through their clicks to extract user's preferences. Moreover, based on extracted preferences the retrieved query's results are re-ranked to be closer to the user interests. The performance of this application has been evaluated against the result set generated by executing the queries using re-ranking algorithm and without re-ranking algorithm. They used precision and recall measures to evaluate the query results. The evaluation results show significant improvement in retrieval time, recall and precision for re-ranking method using user's preference for different user for same queries and different user for different queries. They emphasized that personalized search system help to provide web information that matches a user's personal interests and thus provide more effective and efficient information access. Also, a key feature in developing successful personalized web applications is to build ontological user profiles that accurately represent a user's interests.

Reference [20] introduced MOAT framework, which developed based on Semantic Web principles designed to bridge this gap between free-tagging and semantic annotation. Free tagging suffers from several limitations like ambiguity and heterogeneity problems. Ambiguity and heterogeneity may produce too much noise or silence while the lack of relationship between tags makes difficult to find related content from a given entry point. These limits cannot be easily overcome since tags, from a machine point of view, do not carry any semantics about what they represent, while a human can interpret such semantic problem when tagging or reading some content. Therefore, the proposed framework tried to over on these problems by using URIs of annotation document which is uniquely identity to each resource. To determine the meaning of tag, all different meaning should be listed, then associate them to specific resource. Also, URIs of resource can be used to unify the keys because the URIs are unique; user resource and user tag and resource tag is useful for personalized search.

6. Analysis of Different Directions in Personalization

After discussing some of existing related work in personalization field; different direction in this area may need some analysis. This section concerns with analyzing different directions of personalization based on annotations according to previous researches.

Personalization researches which focus on social annotations as a main source to extracting semantic; distribute their effort into different branches. The distributed efforts may be directed based on the purpose of research and their point of view about improving information retrieval. So, they identify how can effectively use annotation, and in which search process phase.

Nowadays, personalized search directed into analysis user's annotation to be used in three aspects. These aspects can be listed as follow:

- ***Predefined Models***

Several efforts directed to constructing predefined models to support search engines in improving results. These models are developed based on social annotations folksonomy. Researches in personalized IR field rely on exploiting the relation of user interesting, user tags and web resource. In this context, personalized IR may be supported by developing document model, user profile, and mapping them to construct several kinds of relations.

By using annotation, document and tags are classified according to topics and domain. The classification is based on data mining techniques. Then, topic or domain classification is used in developing document profile and user profile.

The main purpose of constructing document profile is identifying the domain of search and linking it to a specific model topic. So, it may facilitate query answering specially it is developed based on users perceptions. Moreover, user profile may be considered as main part of personalized search, where it represents users' preferences through user's descriptive actions (e.g. annotations). Furthermore, the core point is the mapping between document model and user profile, where it provides personalized search engine results.

7. Query Expansion and Re-Ranking

One of personalization methods is expand user's query based on their interests. The user's interests are predefined in user profile, which developed based on user tags, behaviors, and navigation. Moreover, to expand query document model may be used through the mapping which constructed between user profile and document model. So, query expansion may support search engines to be closed to user expectation.

Furthermore, many researches directed their efforts to personalize the retrieved result based on user's query. Firstly, the result of user's query may be retrieved based on document profile, then expand query by using user profile based on user's interests. So, the retrieved results are merged and filtered. The merged result is personalized result which expected to satisfy user needs.

8. Personalization Based on Semantic Model

Although many researches attempt to avoid search engines problems and concern with Personalization Information retrieval, still personalized search suffer from semantic problems. The semantic problems are ambiguity and polysemy for both tag folksonomy and query terms. Thus, for solving semantic problems conceptual model like ontology may considered as support.

Ontology in personalization field may be used in one of two ways. The first is for mapping tag or user interests concepts to domain/upper ontology. This may support search engines by adding level of standardization and

providing semantic agreement (especially in a specific domain). Moreover, the second used of ontology is for developing ontological user profile. This facilitates mapping constructing among tag, user, and document. So, ontology supports experts in improving retrieval process and more reliably personalizing search

9. Limitations

The review study is concerned with some main annotations factors which identify the scope of research. One of the main factors is the web resource format. Search engine deals daily with different resource formats like document, images, video, etc. the review study focus on the textual web resources and ignore other formats. In addition, one of the limitations is language, where the unified language facilitates linguistic analysis and knowledge extraction without confusing. So, the scope of the paper is the English web resources which annotated by English annotations.

The above reviewed researches concerns with extracting taggers' personality through analyzing their tags. The personal user's data is not part of our contribution. Also, the click factor is out of scope. So, the review study considers the social annotation as the only reference to know who the user is and his interests and domain.

10. Conclusion

Nowadays, IR researchers concern with personalized search as one of web 3.0 requirements, but this branch still needs more efforts. These efforts may be direct to discovering user interests to be more reliable, and analyzing tags with respect semantic problems. Further, one of challenges which needs more stress is changeability of user preferences. So, an important question have to be put on; "is personalization useful and affective in general purpose search or for domain based search?"

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